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Fabrication of Rayleigh-Taylor Instability Experiment Targets*

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Because of the concern for growth of Rayleigh-Taylor (R-T) instabilities, surfaces of targets for implosion experiments must be exceptionally smooth. The "100 Å" surface smoothness requirement could be conservative, expensive insurance against R-T instabilities. Will unstabilities grow at 500 Å or 1000 Å surface smoothness? What are the approaches to minimize the R-T instability effects? The present R-T experiments are designed to answer some of those questions.

Our approach to the problem has been to fabricate planar targets with known defects so that their performance can be compared with theoretical predictions. Since it is more difficult to make theoretical calculations for a point-defect, our R-T experiments are designed to test continuous, single-frequency sinusoidal defects of various wavelengths and peak-to-valley heights.

These flat disks targets are made with sinusoidal defects of wavelengths (λ) of 10, 20, 30, and 50 μm, and peak-to-valley heights (η) of 0.2, 0.5, 1, 2, 3, 4 and 5 μm(see figure 1). Various combinations of λ and η are needed and in all cases, a surface smoothness of 500 Å is desired. The average target thickness depends on the target material, ranging from 20 μm for glass to 40 μm for hydrocarbon (CH) polymers. The range of target materials is confined to materials similar to those which are proposed to be used in ICF targets. Glass, CH polymer, and polyvinyl chloride (PVC) were prepared for our initial experiments.

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Based on the physical dimensions and the materials desired for the R-T targets, we decided to fabricate the targets by replication from a precision machined mold. Different molds can be produced ahead of time and many R-T target can be replicated quickly from the existing molds.

The molds, 2-cm-diam by 0.6-cm-thick OFHC copper disks with either gold or copper electroplated surfaces were all turned on the precision diamond turning machine. Patterns cut on the electroplated materials gave the smoothest surfaces. The all copper mold can also be dissolved easily without affecting the R-T target material whenever there are problems in releasing the R-T target from the mold.

The R-T target materials under consideration can all be dissolved in solvents. Thus the targets can be replicated by spreading a solution of the target material onto the mold and removing the film from the mold when the solvent has evaporated. We spread a uniformly thick liquid layer on the 2-cm-diam surface using a spinning technique. By adjusting the spinning speed and the viscosity of the liquid, a uniform layer in the thickness range of interest is obtained.

We have completed eight mold types containing a total of 58 target patterns. The surface smoothness varies from 0.05 to 0.1 μm depending on the peak-to-valley height of the R-T target pattern. With liquid glass($Na_2O.xSiO_2$), which is water based, the results were poor because the water did not wet the metal surface, even with the addition of a few wetting agents. We have been successful using the liquid molding technique with liquids that wet the mold surface. We have produced polystyrene and PVC targets that meet the specifications. A typical mold and its replicated polystyrene layer are shown in figure 2.

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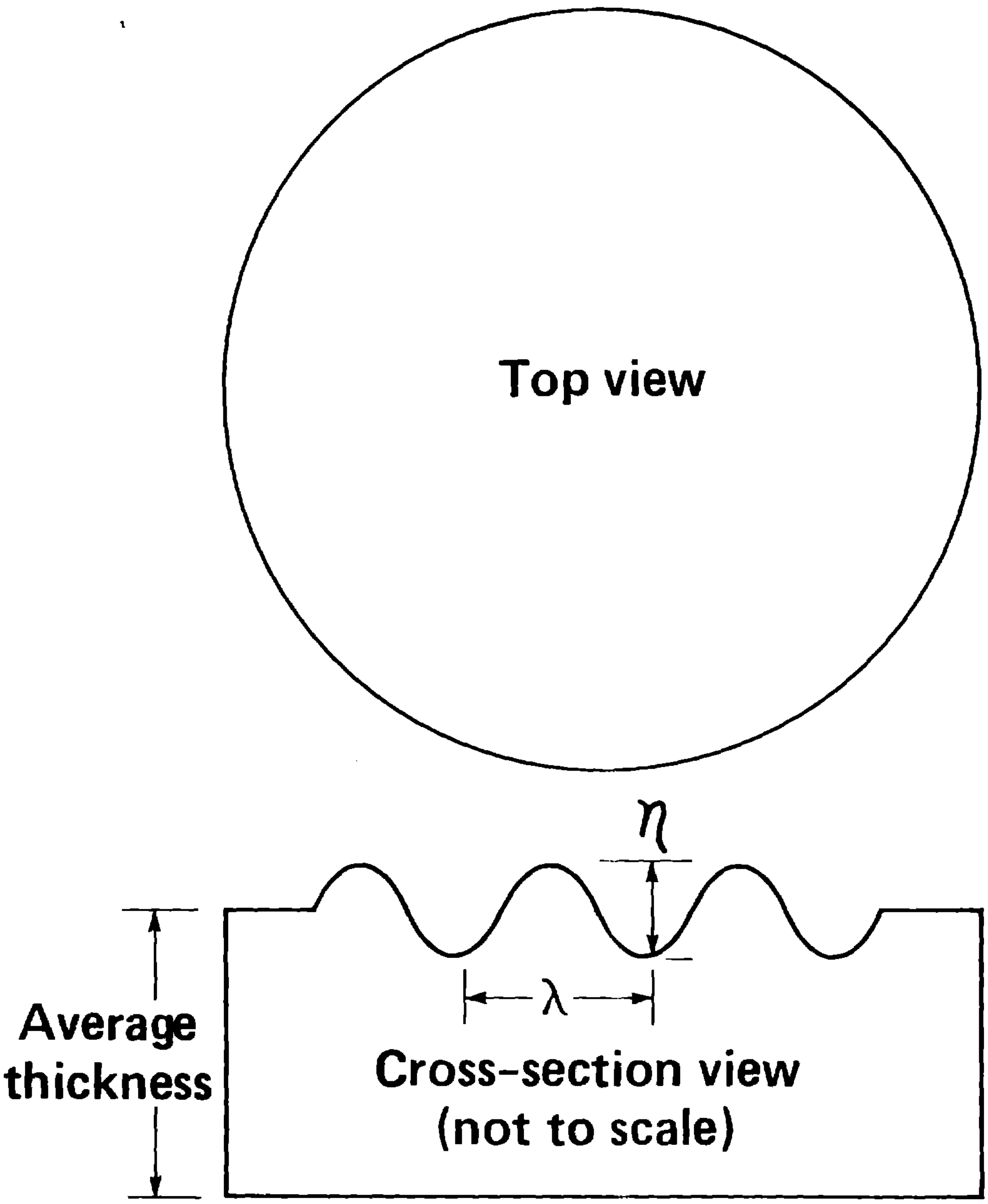
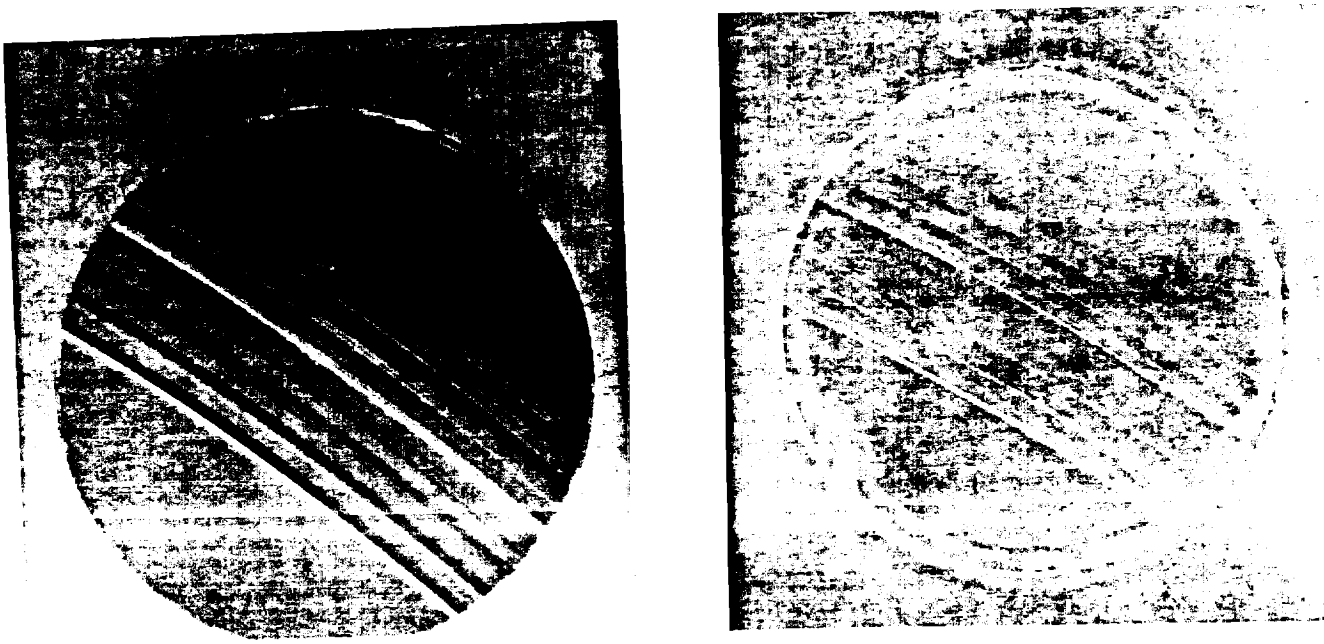


Fig. 1. Definition of λ and η for machined-in R-T target defects



scale: 1 cm

Fig. 2. A precision machined R-T target mold and a replicated polystyrene layer by liquid molding technique